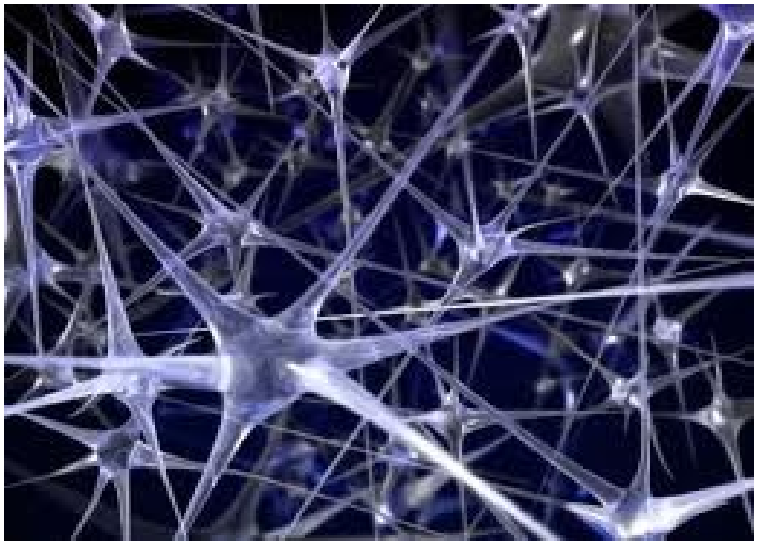
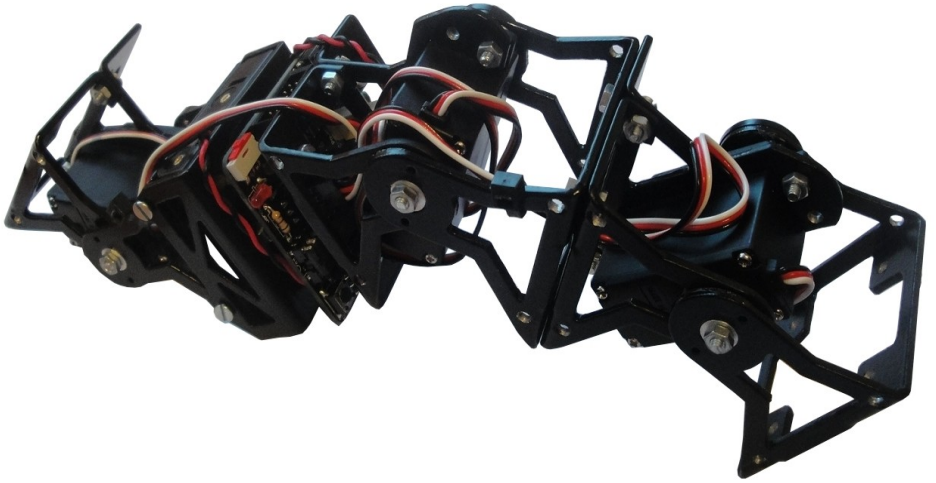
A Distributed Neural Controller for Locomotion in Linear Modular Robotic Configurations





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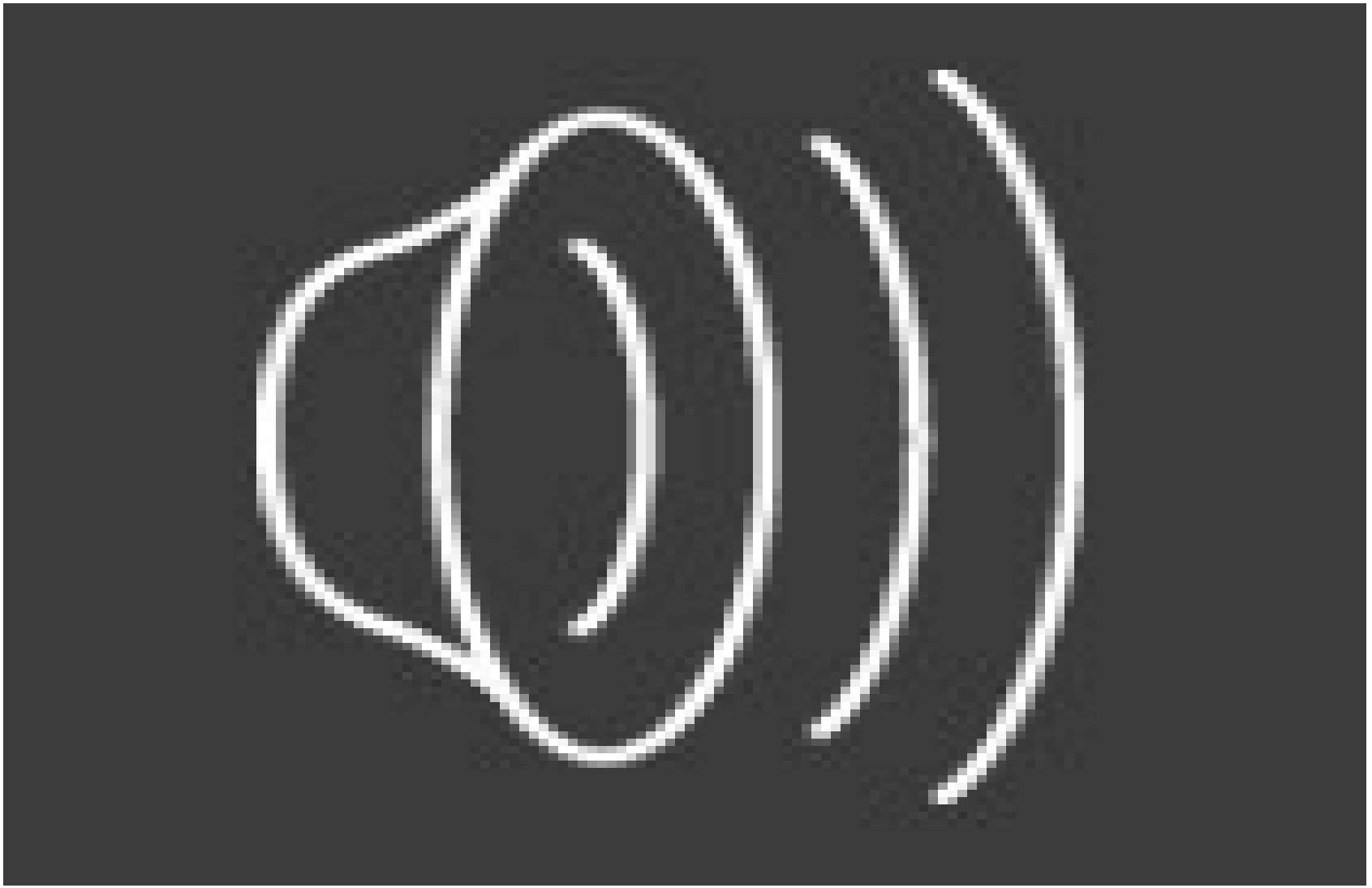
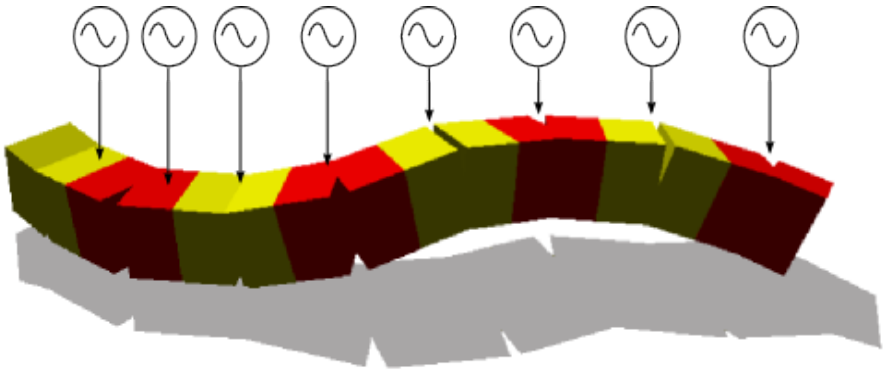


Sinusoidal Oscillator



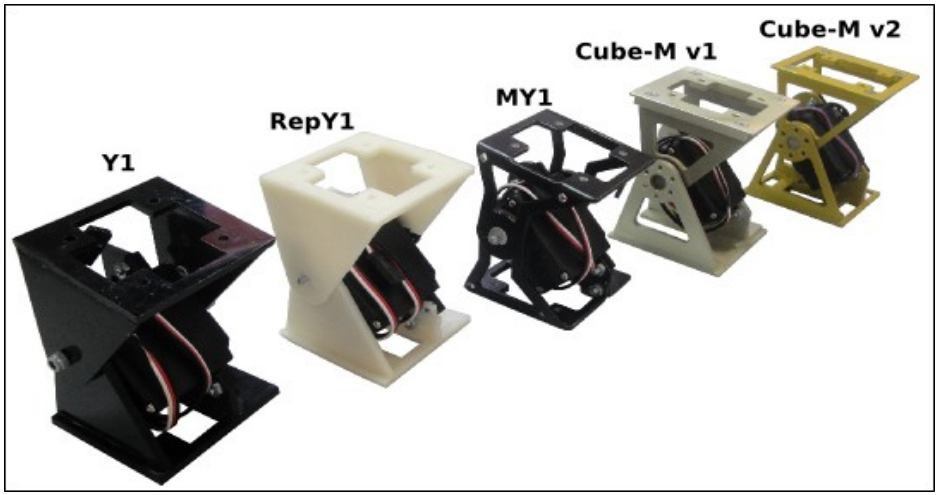
Sinusoidal Oscillator:

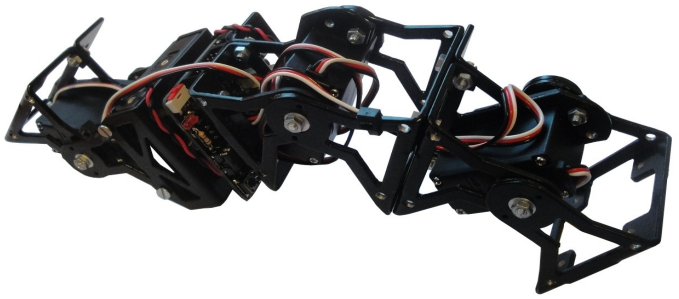
$$\varphi_i(t) = A_i \sin\left(\frac{2\pi}{T} t + \psi_i\right) + O_i$$

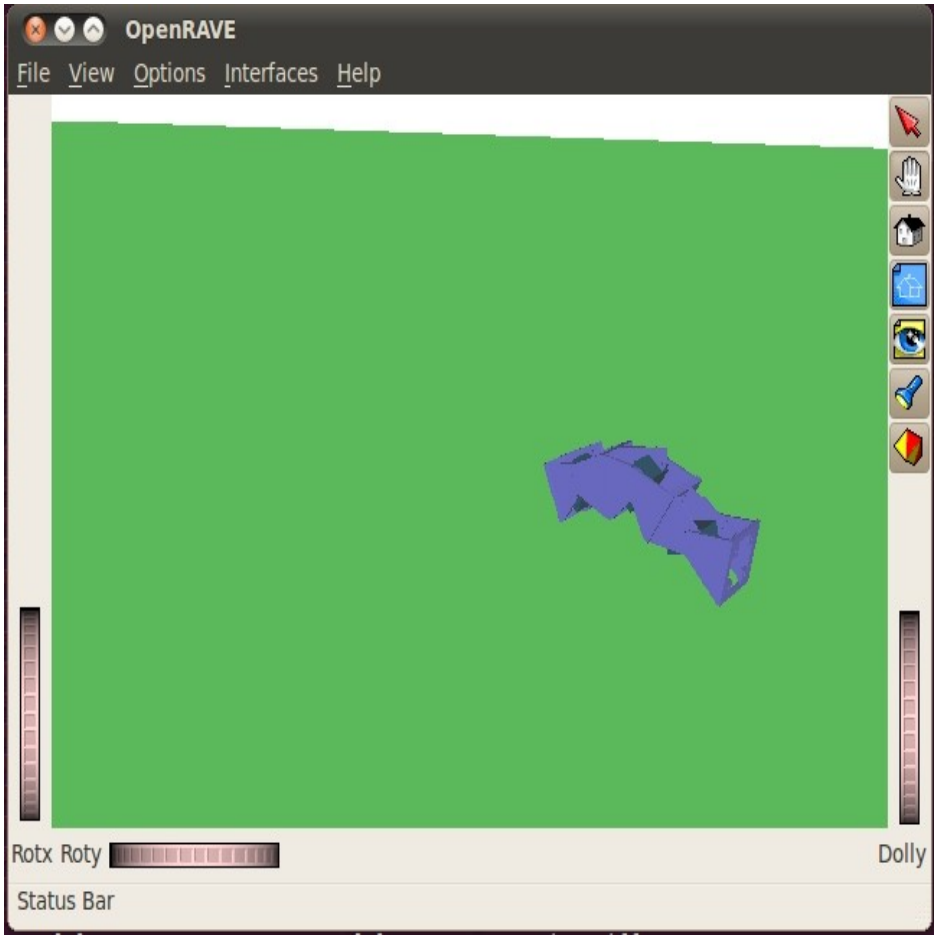
Objective

1. Distributed
2. Homogeneous
3. Adaptive
4. Fault tolerant

Y1 in OpenRAVE

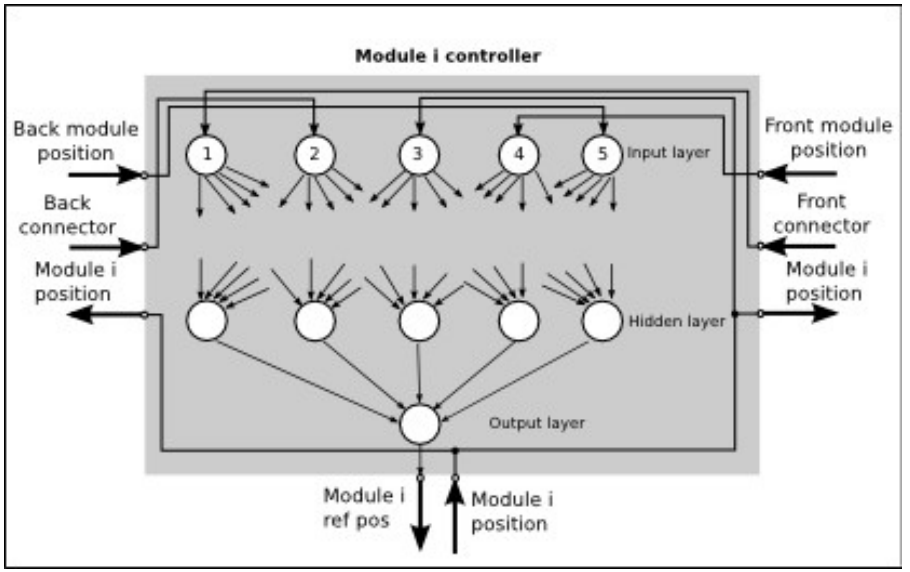


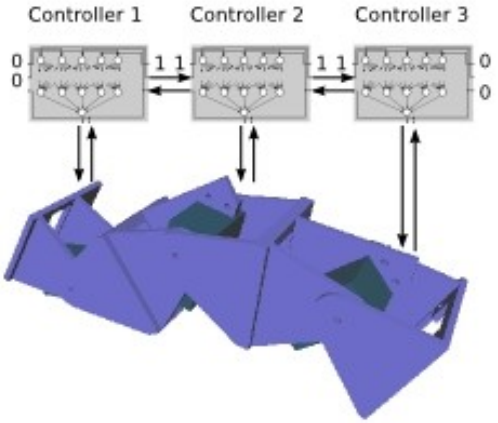




Neural Controller

- **Input layer**:
  - 1-2: Connector information
  - 3: Feedback from self actuator
  - 4-5: Feedback from neighbouring module's actuator
- **Hidden layer**:
  - One hidden layer with five hidden neurons
- **Output layer**:
  - One output neuron connected to the actuator



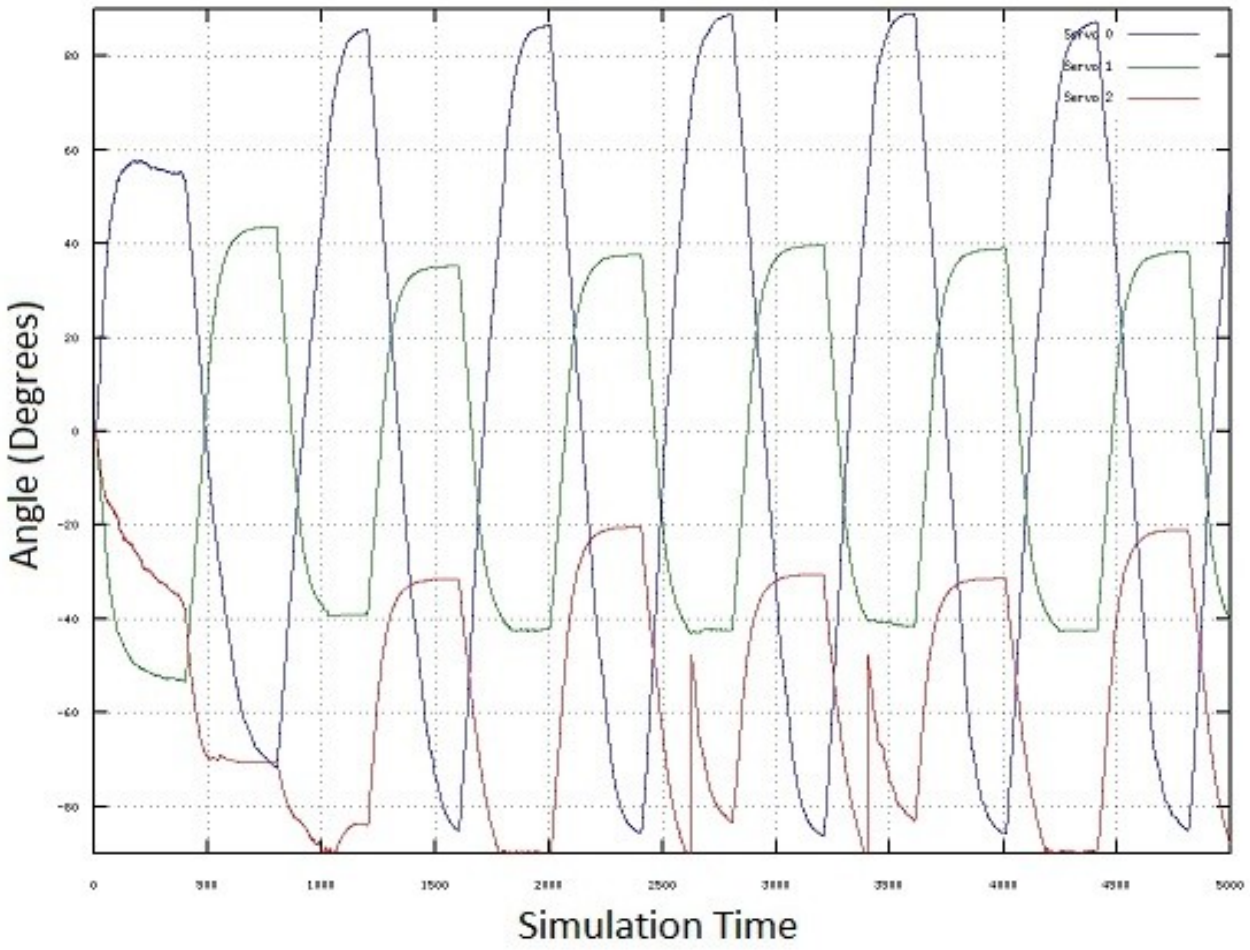


Evolution

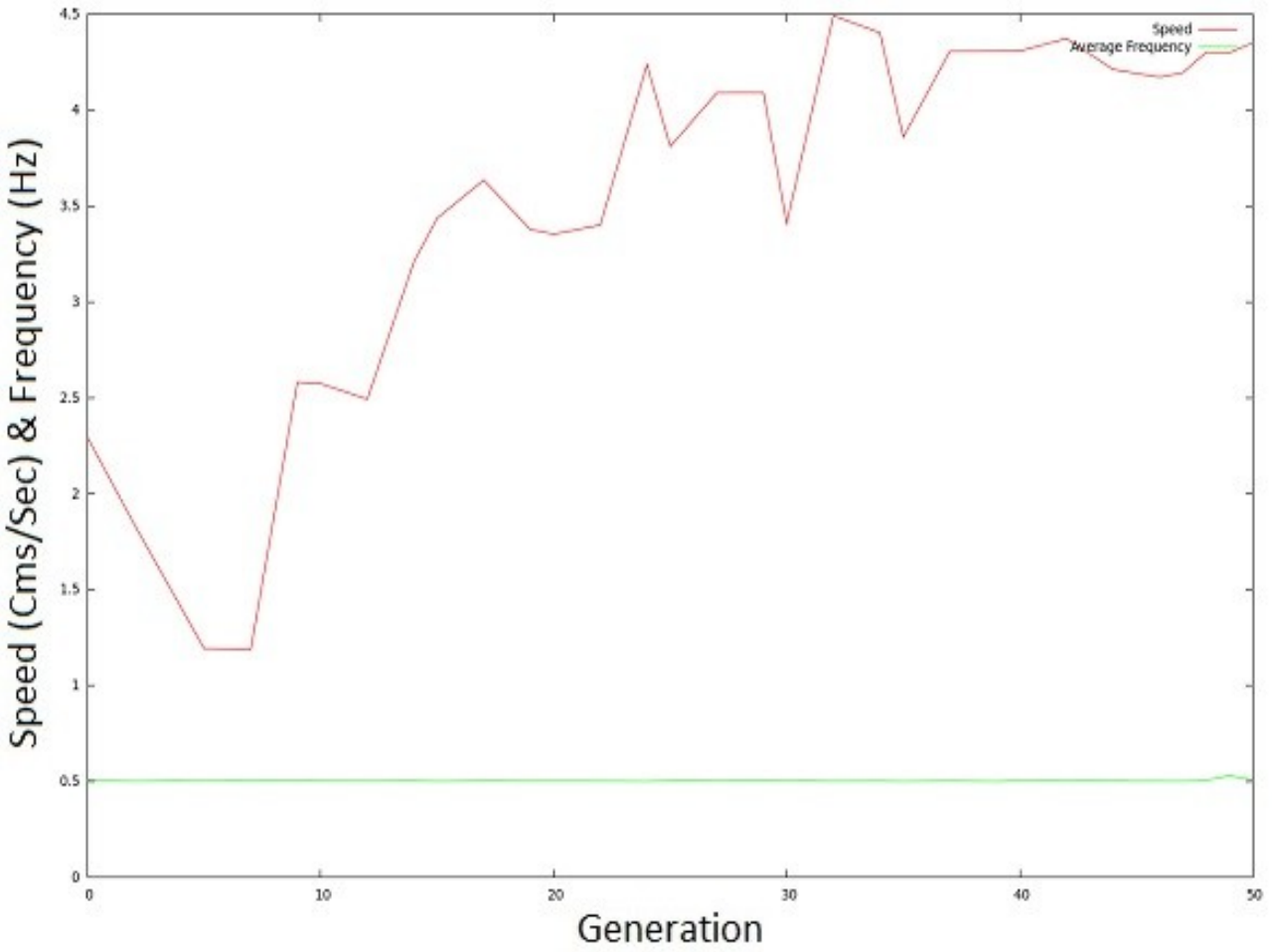
- **Genetic Algorithm**
  - Roulette Wheel selection method
  - Intermediate Recombination method
  - Fitness: Displacement measured as euclidean distance from origin
  - Evaluation time: 50 seconds.

Parameters	Values
Population size	50
Generations	100
Crossover percentage	50%
Elite population retained	12.5%
Mutation rate	1/Size of genome

Frequency controlled method



Frequency controlled method



Frequency adaptive method

$$|\theta_{ANN} - \theta_{t_i}| \leq \alpha \quad (1)$$

$$|\theta_{t_i} - \theta_{t_{i-x}}| \leq \beta \quad (2)$$

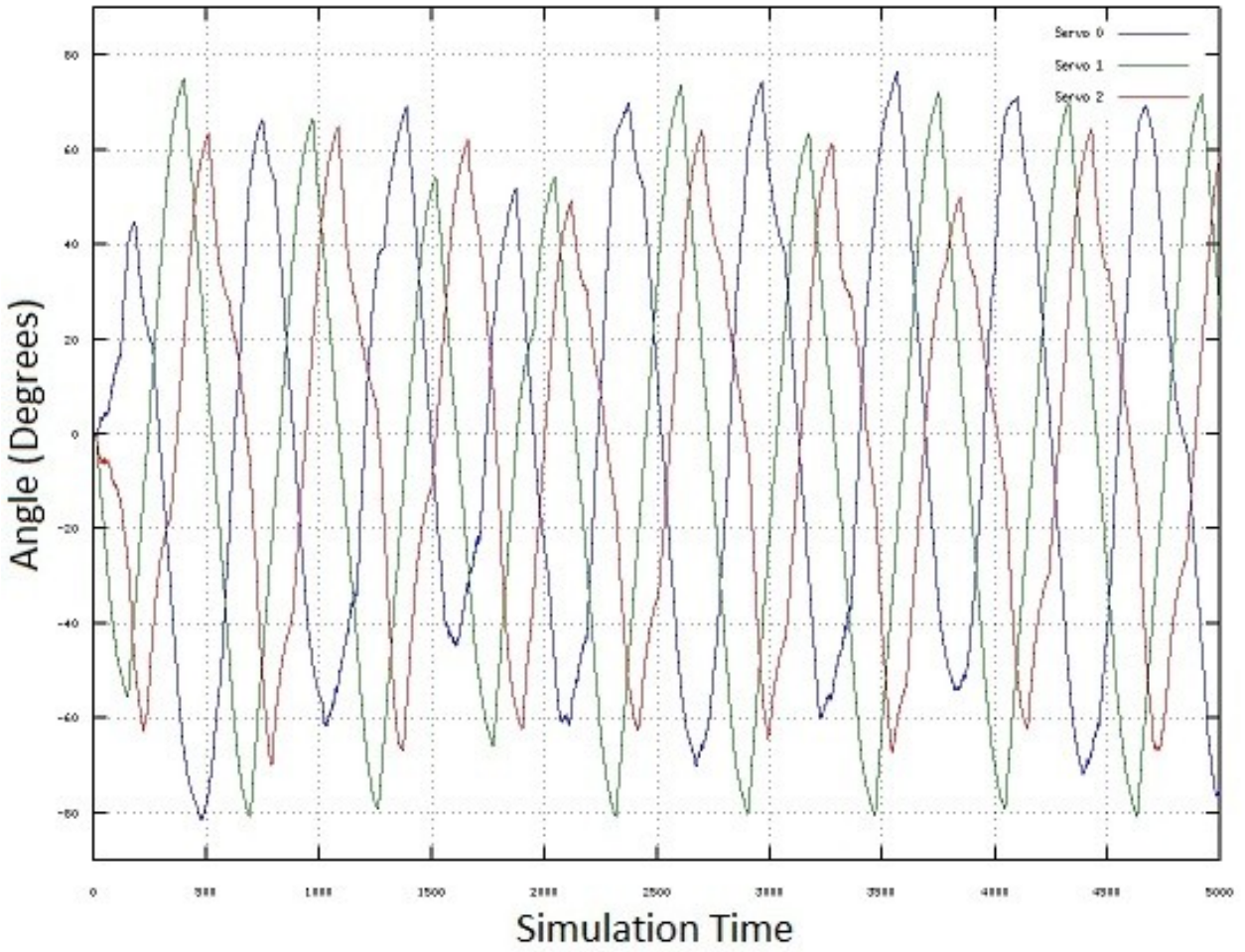
Where,

θ_{ANN} : Output from the ANN

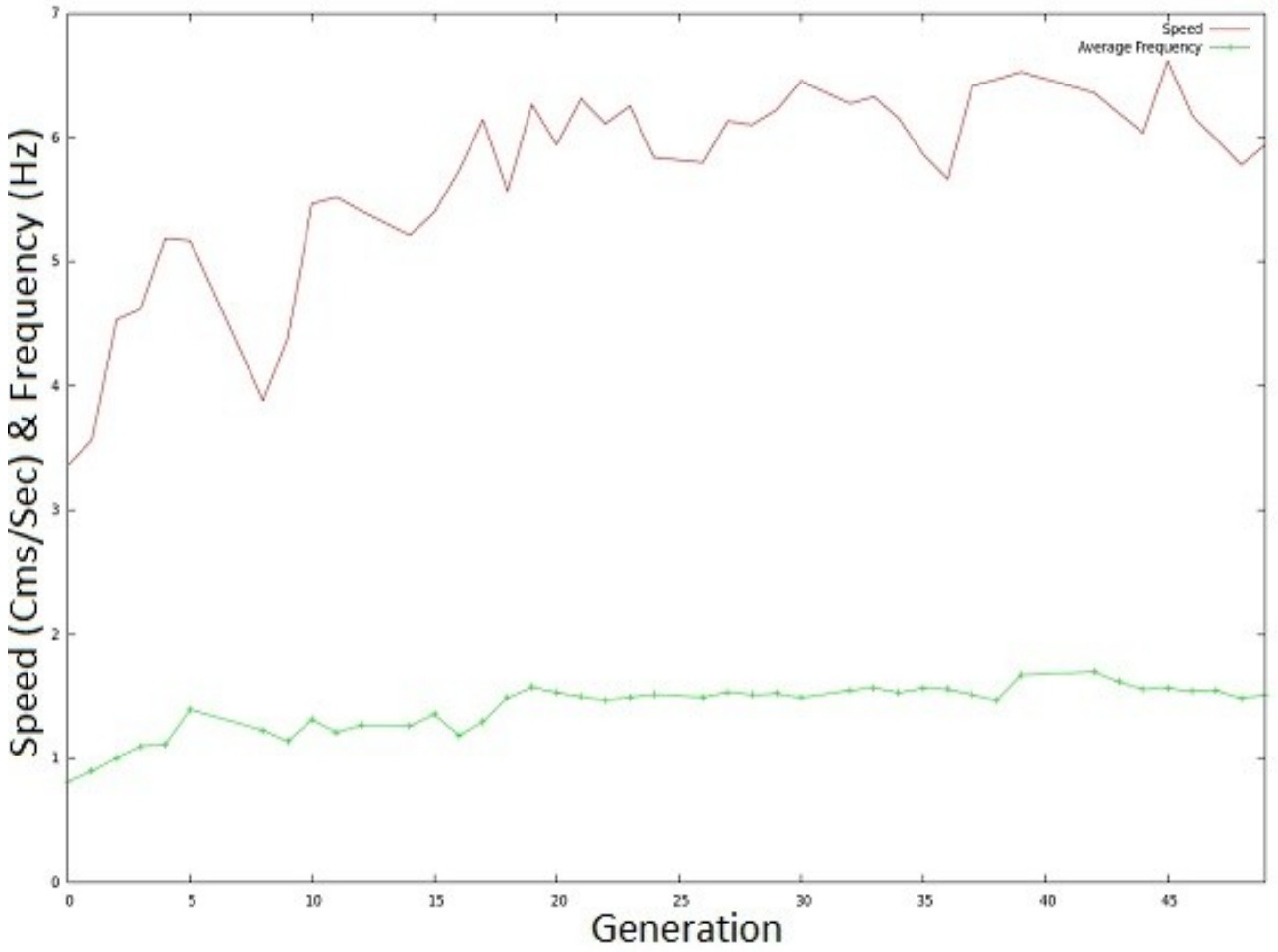
θ_{t_i} : Angle of the actuator at time ti

α β and x are constants.

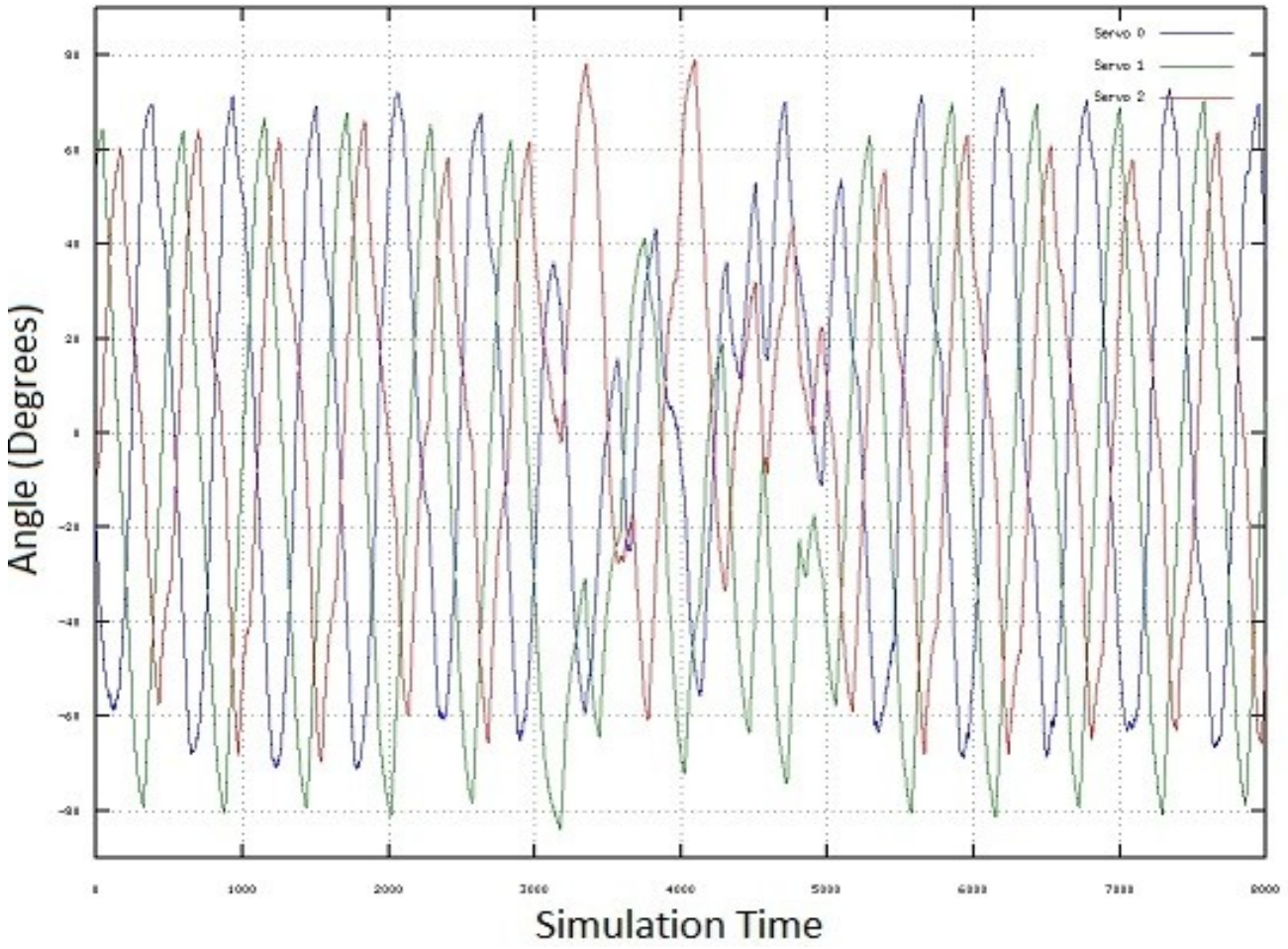
Frequency adaptive method



Frequency adaptive method



Limit cycle behaviour



Conclusion

- Proposed model validated for locomotory oscillations.
- Fault tolerance with limit cycle behaviour.
- Fast convergence to optimal oscillatory pattern.

Future work

- Validate this model on the real Y1 modular robots.
- Adaptive behaviour for locomotion on different surfaces
- Evolve the topology to both complexify and to find the minimal neural architecture.

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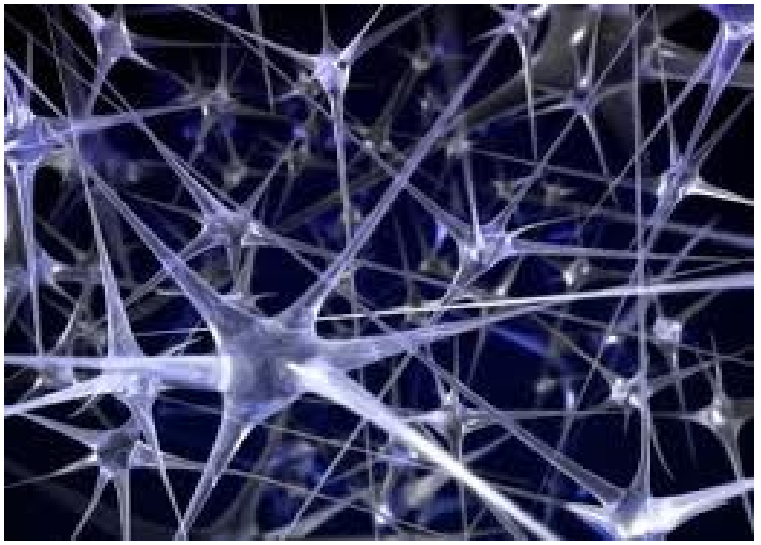

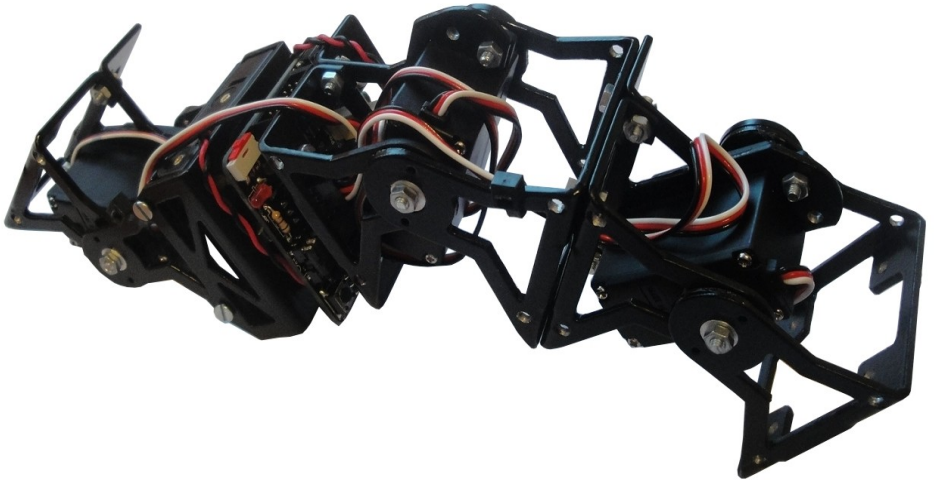

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